JC535 U.S. PTO
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PTO/SB/05 (4/98)
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UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 C.F.R. § 1.53(b))

Attorney Docket No.	
First Inventor or Application Identifier	
Title	
Express Mail Label No.	

JC892 U.S. PTO 09/709896 11/13/00

APPLICATION ELEMENTS
See MPEP chapter 600 concerning utility patent application contents.

ADDRESS TO: **Assistant Commissioner for Patents, Box Patent Application, Washington, DC 20231**

1. [X] * Fee Transmittal Form (e.g., PTO/SB/17) (Submit an original and a duplicate for fee processing)
2. [X] Specification [Total Pages 19] (preferred arrangement set forth below)
   - Descriptive title of the Invention
   - Cross References to Related Applications
   - Statement Regarding Fed sponsored R & D
   - Reference to Microfiche Appendix
   - Background of the Invention
   - Brief Summary of the Invention
   - Brief Description of the Drawings (if filed)
   - Detailed Description
   - Claim(s)
   - Abstract of the Disclosure
3. [X] Drawing(s) (35 U.S.C. 113) [Total Sheets 2] INFORMAL
4. Oath or Declaration [Total Pages 2]
   a. [X] Newly executed (original or copy)
   b. [ ] Copy from a prior application (37 C.F.R. § 1.63(d)) (for continuation/divisional with Box 16 completed)
      i. [ ] DELETION OF INVENTOR(S) Signed statement attached deleting inventor(s) named in the prior application, see 37 C.F.R. §§ 1.63(d)(2) and 1.33(b).

*NOTE FOR ITEMS 1 & 13: IN ORDER TO BE ENTITLED TO PAY SMALL ENTITY FEES, A SMALL ENTITY STATEMENT IS REQUIRED (37 C.F.R. § 1.27), EXCEPT IF ONE FILED IN A PRIOR APPLICATION IS RELIED UPON (37 C.F.R. § 1.28).

5. [ ] Microfiche Computer Program (Appendix)
6. Nucleotide and/or Amino Acid Sequence Submission (if applicable, all necessary)
   a. [ ] Computer Readable Copy
   b. [ ] Paper Copy (identical to computer copy)
   c. [ ] Statement verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

7. [ ] Assignment Papers (cover sheet & document(s))
8. [ ] 37 C.F.R.§3.73(b) Statement (when there is an assignee) [ ] Power of Attorney
9. [ ] English Translation Document (if applicable)
10. [X] Information Disclosure Statement (IDS)/PTO-1449 [ ] Copies of IDS Citations
11. [ ] Preliminary Amendment
12. [X] Return Receipt Postcard (MPEP 503) (Should be specifically itemized)
13. [X] * Small Entity Statement(s) (PTO/SB/09-12) [ ] Statement filed in prior application, Status still proper and desired
14. [ ] Certified Copy of Priority Document(s) (if foreign priority is claimed)
15. [ ] Other: ....

16. If a CONTINUING APPLICATION, check appropriate box, and supply the requisite information below and in a preliminary amendment:

[ ] Continuation [ ] Divisional [ ] Continuation-in-part (CIP) of prior application No: ______/______

Prior application information: Examiner ______ Group / Art Unit: ______

For CONTINUATION or DIVISIONAL APPS only: The entire disclosure of the prior application, from which an oath or declaration is supplied under Box 4b, is considered a part of the disclosure of the accompanying continuation or divisional application and is hereby incorporated by reference. The incorporation can only be relied upon when a portion has been inadvertently omitted from the submitted application parts.

17. CORRESPONDENCE ADDRESS

[ ] Customer Number or Bar Code Label (Insert Customer No. or Attach bar code label here) or [X] Correspondence address below

Name	Leo J. Aubel				
Address	111 Rivershire Lane				
City	Lincolnshire	State	Illinois	Zip Code	60069
Country	USA	Telephone	847-634-8923	Fax	847-634-8985

Name (Print/Type)	Leo J. Aubel	Registration No. (Attorney/Agent)	18,382
Signature	Leo J Aubel	Date	11/9/00

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Patent fees are subject to annual revision.
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TOTAL AMOUNT OF PAYMENT ($)

Complete if Known	
Application Number	
Filing Date	
First Named Inventor	Gueorgui Gueorguiev
Examiner Name	
Group / Art Unit	
Attorney Docket No.	

METHOD OF PAYMENT (check one)

1. ☐ The Commissioner is hereby authorized to charge indicated fees and credit any overpayments to:

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FEE CALCULATION

1. BASIC FILING FEE

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
101	690	201	~~345~~ 355	Utility filing fee	355
106	310	206	155	Design filing fee	
107	480	207	240	Plant filing fee	
108	690	208	345	Reissue filing fee	
114	150	214	75	Provisional filing fee	

SUBTOTAL (1) ($) 355

2. EXTRA CLAIM FEES

	Claims		Extra Claims		Fee from below		Fee Paid
Total Claims	12	-20** =	0	X	0	=	—
Independent Claims	3	- 3** =	0	X	0	=	—
Multiple Dependent					—	=	—

***or number previously paid, if greater; For Reissues, see below*

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description
103	18	203	9	Claims in excess of 20
102	78	202	39	Independent claims in excess of 3
104	260	204	130	Multiple dependent claim, if not paid
109	78	209	39	** Reissue independent claims over original patent
110	18	210	9	** Reissue claims in excess of 20 and over original patent

SUBTOTAL (2) ($) —

FEE CALCULATION (continued)

3. ADDITIONAL FEES

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
105	130	205	65	Surcharge - late filing fee or oath	
127	50	227	25	Surcharge - late provisional filing fee or cover sheet.	
139	130	139	130	Non-English specification	
147	2,520	147	2,520	For filing a request for reexamination	
112	920*	112	920*	Requesting publication of SIR prior to Examiner action	
113	1,840*	113	1,840*	Requesting publication of SIR after Examiner action	
115	110	215	55	Extension for reply within first month	
116	380	216	190	Extension for reply within second month	
117	870	217	435	Extension for reply within third month	
118	1,360	218	680	Extension for reply within fourth month	
128	1,850	228	925	Extension for reply within fifth month	
119	300	219	150	Notice of Appeal	
120	300	220	150	Filing a brief in support of an appeal	
121	260	221	130	Request for oral hearing	
138	1,510	138	1,510	Petition to institute a public use proceeding	
140	110	240	55	Petition to revive - unavoidable	
141	1,210	241	605	Petition to revive - unintentional	
142	1,210	242	605	Utility issue fee (or reissue)	
143	430	243	215	Design issue fee	
144	580	244	290	Plant issue fee	
122	130	122	130	Petitions to the Commissioner	
123	50	123	50	Petitions related to provisional applications	
126	240	126	240	Submission of Information Disclosure Stmt	
581	40	581	40	Recording each patent assignment per property (times number of properties)	
146	690	246	345	Filing a submission after final rejection (37 CFR § 1.129(a))	
149	690	249	345	For each additional invention to be examined (37 CFR § 1.129(b))	

Other fee (specify) ____________________

Other fee (specify) ____________________

*Reduced by Basic Filing Fee Paid

SUBTOTAL (3) ($) —

SUBMITTED BY Complete (*if applicable*)

Name (Print/Type)	LEO J AUBEL	Registration No. (Attorney/Agent)	18382	Telephone	847 634 8923
Signature	Leo J Aubel			Date	11/9/00

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STATEMENT CLAIMING SMALL ENTITY STATUS (37 CFR 1.9(f) & 1.27(b))--INDEPENDENT INVENTOR	Docket Number (Optional)

Applicant, Patentee, or Identifier: ______

Application or Patent No.: ______

Filed or Issued: ______

Title: Irradiation System and Method Using X-Ray Reflector and Gamma Ray Reflector

As a below named inventor, I hereby state that I qualify as an independent inventor as defined in 37 CFR 1.9(c) for purposes of paying reduced fees to the Patent and Trademark Office described in:

- [x] the specification filed herewith with title as listed above.
- [ ] the application identified above.
- [ ] the patent identified above.

I have not assigned, granted, conveyed, or licensed, and am under no obligation under contract or law to assign, grant, convey, or license, any rights in the invention to any person who would not qualify as an independent inventor under 37 CFR 1.9(c) if that person had made the invention, or to any concern which would not qualify as a small business concern under 37 CFR 1.9(d) or a nonprofit organization under 37 CFR 1.9(e).

Each person, concern, or organization to which I have assigned, granted, conveyed, or licensed or am under an obligation under contract or law to assign, grant, convey, or license any rights in the invention is listed below:

- [x] No such person, concern, or organization exists.
- [ ] Each such person, concern, or organization is listed below.

Separate statements are required from each named person, concern, or organization having rights to the invention stating their status as small entities. (37 CFR 1.27)

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28(b))

Gueorgui Gueorguiev		
NAME OF INVENTOR	NAME OF INVENTOR	NAME OF INVENTOR
G. Gueorguiev		
Signature of inventor	Signature of inventor	Signature of inventor
Nov. 8, 2000		
Date	Date	Date

IRRADIATION SYSTEM AND METHOD USING X-RAY AND GAMMA-RAY REFLECTOR

Background of Invention:

In efforts to improve the overall efficiency of present day irradiation systems, a number of attempts have been made to better utilize the energies developed in the systems. For example, in X-ray irradiation systems various schemes have been developed to obtain a higher percentage of usefulness of the rays produced by X-ray tube. That is, various systems have been developed in attempts to increase the percentage of the energy converted to X-rays that is actually utilized to irradiate a product or item. Further, various other systems and methods have been explored to provide a more even distribution of the X-rays throughout the surface area of the

product being irradiated.

Also, in irradiation systems using gamma-quanta irradiation sources such as cobalt-60 and cesium 137, various efforts have been made to provide more even irradiation throughout the thickness of the product being irradiated. In prior art systems, the absorbed energy distribution effective on the product being irradiated depends on various factors including the material of the target, the distance of the source to the target and on the geometry of the irradiation procedure. The present invention provides a unique system and method for obtaining a means for improving the efficiency of the desired radiation.

The present invention improves the methodology and structure of irradiation systems by utilizing, the principal that in many irradiation procedures, the irradiation provided to the product penetrates that product and there is a significant amount of photons which penetrate and exit the product.

It is an object of the present invention to effectively reuse the photons which have passed through the irradiated product and exited the product. These exiting photons are reflected back to the product to re-irradiate the product to thereby provide more efficient irradiation.

It is another object of the invention to utilize radiation exiting the product, which has heretofore been wasted, to re-irradiate the product.

It is another object of the invention to provide a more even distribution of an absorbed dose throughout the surface area of the product being irradiated and throughout the thickness of the product.

It is a further object purpose of this invention to utilize unique irradiation techniques to provide an improved irradiation system and method.

Summary of the Invention:

The system and method of the invention utilize a source of X-ray or gamma ray irradiation which is directed to irradiate a product. The rays penetrate the product, and significant amounts of radiation (rays) exit the product on the opposite surface of the product. A radiation reflective low Z (atomic number), high density material is provided to reflect the rays penetrating the product. The reflected rays are directed and reflected back to the product to again irradiated the product thereby utilizing the reflected rays to provide a "secondary" irradiation source to effectively "re-irradiate" the product.

The foregoing features and advantages of the present invention will be apparent from the following more particular description of the invention. The accompanying drawings, listed herein below, are useful in explaining the invention.

Drawings:

Fig. 1 shows a preferred embodiment of the inventive system and method wherein a reflective, low Z high density material reflects the radiation (X-rays), which exit the product, back to the product to re-irradiate the product;

Fig. 1A is a cross section of a modification of the embodiment of Fig. 1 wherein the sides of the reflector are formed to be vertical (as oriented in Fig. 1);

Fig. 2 is a table showing the percentage increase in the dosage provided by the invention when tested with a water equivalent phantom;

Fig. 3 is a graph showing the percentage increase in the dose provided by the inventive method and structure; and,

Fig. 4 is a table, essentially an extension of the table of Fig. 2 showing the dose distribution in a standard water equivalent phantom positioned between a 160 kV tube and a boron carbide reflector.

Description of the Invention:

The principal of the invention relates to all types of electromagnetic radiation, i.e., electronically produced X-ray and also gamma-quanta emitted after radioactive decay of naturally radioactive isotopes like Cesium-137, Cobalt-57, Cobalt-60 and

all other X-ray emitters. The inventive system is constructed such that the irradiation interacts with the low Z material to obtain as much back scattered radiation as feasible, and with as little absorption of the radiation as practical. The reflector used in the inventive system may be any low Z, high density material; in the various embodiments of the invention, boron carbide, boron and carbon have been used since these three materials appear to be the best for the purpose of the invention. In the embodiment of the invention depicted in Fig. 1, relatively thick (bulk) material from one inch to several inches in thickness is used as the reflector in order to utilize the entire spectrum, i.e., all energies up to 160keV. In the embodiment where mono-energy gamma-quanta from radioactive decay is used the thickness of the reflector can be precisely calculated to obtain maximum effectiveness.

In the embodiment of the inventive system and method as depicted in Fig. 1, an X-ray tube 21 of any suitable known type provides X-rays 22 to irradiate a product/object 23. As described above, the invention is applicable to the other type of irradiation as described above, the principal of the invention is to effectively reuse the photons produced by a source to re-irradiate the product to thereby provide more efficient irradiation system and process. That is, the invention is applicable to various sources of the electromagnetic radiation. The description of

the embodiment of Fig. 1 is thus generally inclusive for the other sources mentioned.

Referring still to Fig. 1, X-rays 22 are directed to enter (penetrate) the upper surface (as oriented in the drawing) of the product. A portion of the radiation (rays), indicated at 22A, penetrates and exits the product at the opposite or lower surface of product 23. Also, as will be appreciated some of the X-rays also exit at the sides of the product. A radiation reflector 24, comprising a low Z (atomic number), high density material such as boron carbide, boron or carbon is positioned to reflect a major portion of the radiation 22B exiting the product 24 back to irradiate the product, effectively from the bottom upwardly.

Note that the term, "high density material" referred to herein, comprises boron, boron carbide, carbon or the like wherein the density is about 2 to 2.5 gr/cm^3. These materials have the highest density amongst the low Z chemical elements. A low Z material is chosen because of lower absorption of the irradiating rays. It is known from physics that the absorption of X-rays and gamma-quanta rises as Z to the 5th power and diminishes by energy as E to the 3.5 power where Z is the atomic number of the absorber and E is the energy of the photons. This means that the low energy photons like X-rays or gamma rays would be highly absorbed by high Z materials. The best absorbers are high Z chemical elements and the best scattering materials, i.e., material with low absorption capability are low Z chemical

elements. It is an additional feature of the high density material used that it diminishes the depth of penetration into the reflector material layer thereby permitting the thickness of the reflecting layer to be decreased. The reflector 24 can comprise a planar surface, and/or the reflector 24 may be contoured to better direct the reflected X-rays back to the product, as depicted in Fig. 1. The reflector should be at least three quarters (3/4)of an inch in thickness, and in the embodiment described with relation to Figs.1-4, the reflector is 10 cm in thickness (2.54cms equals 1inch).

Reflectors of boron carbide , boron and carbon have been used in the inventive system. In one embodiment, boron carbide used as the material for the reflector 24 since it is readily available in the marketplace. All three materials mentioned provide excellent results as a reflector of irradiation rays. Importantly, all three materials are quite stable and will not deteriorate with use. Stated in another way, all three materials can withstand the bombardment of the radiation without any substantial alteration in their photon-reflective characteristics.

A comparison was made of the outputs of reflectors made from each of the mentioned materials, i.e., and it has been found that the outputs from a pure boron reflector as well as from a carbon reflector follow essentially the output curves of a boron carbide. The boron and carbon reflectors actually provide slightly higher

boron carbide. The boron and carbon reflectors actually provide slightly higher peak outputs at the lower energy levels with carbon providing the highest peak outputs. However, as mentioned above boron carbide is used in the embodiment shown because it is generally available, durable and practical. Boron carbide has the highest density (2.52) amongst the three materials noted herein.

In the embodiment of Fig. 1, the reflector 24 has its sides or ends 25 angled upwardly, such that the reflected beam is directed to the bottom surface of the product 23, and also to the sides of the product to provide a more uniform irradiation to the entire product. I should be understood that the reflector 24 can be configured to accommodate products of different sizes and shapes. As depicted in Fig.1A, if the product is circular, the reflector 24 can be configured to have a circular recess 26 and vertical sides 25A of selected thickness, to receive the product and more evenly reflect and re-irradiate its bottom, sides and even the top surface. In the case of electronically produced X-rays, the thickness of the reflector is chosen to effectively reflect the high energy in the broad X-ray spectrum. In the case of a gamma-ray source, it is easier to determine the proper thickness of the reflector, because the thickness can be adjusted (tuned) to only one energy.

Figs. 2 and 3 show the results of tests conducted to quantify the improvement provided by the inventive method and apparatus. The test set-up was modeled to obtain results over a wide band of voltages, i.e., for commercially useful types of

systems. It is, of course, known that water is a standard by which useful X-ray irradiation can be measured, particularly when considering irradiation of blood transfusion bags or containers, meat food products and vegetables.

The analysis to be described in connection with Fig. 2 and Fig. 3 was on a system such as shown in Fig. 1. Specifically, a four (4) cm thick water equivalent phantom 23 comprising water equivalent polystyrene layers was positioned to receive the radiation provided from the tungsten anode of the X-ray tube 21. The results shown in Fig. 2, were obtained when the product was positioned 10 inches from the output port of tube 21. The layers were located between the X-ray tube and the reflector 24 comprised a 10 cm thick flat boron carbide member. A standard aluminum or copper filter, not shown, filtered the X-rays from X-ray tube 21.

In Fig. 1, for purposes of depiction of the X-rays 22A penetrating the product 23 and the depiction of the reflected X-rays 22, the space between the product 23 and reflector 24 has been exaggerated. Preferably, the upper surface of reflector 24 is placed in a position closely adjacent the bottom surface of the product. For example, when the product is mounted on a conveyor belt, the reflector is mounted immediately below the belt. The test results obtained in Figs. 2-4, were obtained with the upper surface of the reflector 24 in position essentially

abutting the bottom of the phantom product.

For the comparisons indicated in Figs. 2 and 3, the system was first operated without the reflector 24 and readings taken of the data obtained. Next, the reflector 24 was mounted in the system and readings taken of this data. Fig. 2 is a table showing the dose distribution in the 4cm thick water equivalent phantom product (standard layered phantom comprising suitable layers of plastic) irradiated by a 160 kV X-ray tube. It was found that the dose distribution decreases almost linearly from the top surface to the bottom surface of the phantom. Without a reflector 24 and assigning the value of 100% to the dosage at the top surface, it was found that the dosage at the middle (at the 2cm thickness) of the phantom was 76% of the dosage at the top of the phantom, and the dosage at the bottom surface was 49%. With the boron carbide reflector 24 placed in position in accordance with the invention as indicated in Fig. 1, the dosage at the middle of the phantom was 90% percent of the dosage at the top surface, and the dosage at the bottom surface was 70% of the dosage at the top surface. That is, the dosage distribution was improved by about 14% at the middle of the phantom and 21% at the bottom of the phantom. The table of Fig. 2 shows the *actual* increase in the dosage (when using a 160 kV tube) as a result of providing the reflector 24.

The graph of Fig. 3 shows the results of *calculations* indicating the

percentage increase as X-ray sources operating at higher kV's are used. As is known, X-ray tube sources are used in the 160-300 kV range; above 300kV, electron accelerators are used as the source. In the graph of Fig. 3, the axis of abscissas indicates the kV (voltages) of respective X-ray sources having accelerating voltages varying from 160 kV to 10 MV. The axis of ordinates shows the dose increase in percentage. At a voltage of 160 kV, the percentage increase is about 72.5%; at 300 kV the percentage increase is about 42.5%; and at 1MV the increase is about 37.5%. Note that the percentage of increase is calculated to remain essentially constant from 1MV to 10 MV.

The table of Fig. 4 shows the dose distribution in a 4-cm water phantom positioned between a 160 kV X-ray tube and a boron carbide reflector. The table shows that, for the system depicted, the reflector compensates for distance variation between the tube and the product. Note that the dose ratio (dose at the top surface/ dose at the bottom surface of the product) remains quite level for the distances from 8 inches to 16 inches. In the prior art systems, i.e., systems not using the inventive reflector system, the effective dosage varies as the reciprocal of the square of the distance between the product and the source. Thus a significant feature and an advantage of the inventive system and method are that it compensates for the influence of the increase in distance by between the source and the product by using

a radiation reflector. As mentioned above, in prior art systems the effective dosage varies as the reciprocal of the square of the distance ($1/r^2$) i.e., low r— high dose, and high r—low dose where r is the distance between the source and the item or product being irradiated. This of course means that in prior art systems, when the product being irradiated is positioned close to the source, the surface of the product closest to the source receives quite different amounts of radiation than the surface of the product farthest from the source i.e., the uniformity of irradiation becomes worse as the distance between the source and the item is decreased. It can be readily appreciated that in prior art systems, the dose uniformity between the top and bottom surfaces of a product is better when the product is positioned at a greater distance than when it is positioned closely to the source, as can be readily determined mathematically. In such prior art systems there are several variables which may not vary linearly. For example as mentioned, the effective dosage varies as the square of the distance between the tube and the product, the thickness of the product affects the dosage. In contrast to the prior art, in the inventive system the product can be positioned closer to the source and get more radiation in the entire volume of the product without worsening the *top/bottom ratio;* this is due to the fact that the reflector provides a compensating factor in that the reflector helps the bottom surface obtain more absorbed dose. In the inventive system, the thickness

of the reflector also affects the dosage but can also provide a compensating factor.

The specific data shown in the tables of Figs. 2 and 4 may vary somewhat for different voltages, distances, and the thicknesses of the product and reflector. However, calculations indicate the compensating effect indicated in the table is generally applicable when a reflector in accordance with the invention is utilized. It should be understood that the inventive system applies to reflectors using any low Z, high density material although boron, boron carbide and carbon are the best materials to use for the inventive purposes.

An important advantage provided by the inventive system and method is that the product is more uniformly irradiated throughout the *thickness* of the product. Further, the inventive system provides a more even irradiation throughout the *surface area* of the product, i.e., the inventive system equalizes the doses absorbed by the central area of the product surface and the doses absorbed by the peripheral area of the surface which may be at different distances from the source (see Fig. 1).

Federal regulations require that the surface of the product that is farthest away from the ray source be irradiated within a certain range of the irradiation effective at the surface of the product closest to the ray source. The basis for this requirement is that the irradiation applied to various products must be effective to fully penetrate the thickness of the product, and must provide a uniform dose,

within prescribed ranges, throughout the thickness of the product. In compliance with these regulations, the inventive system and method provide irradiation to the product from multiple sides by using a unique system and method comprising a single source of radiation and a radiation reflector which provides a more uniform dose to the product, i.e., it tends to equalize and balance the irradiation of the product from a single ray source throughout the surface area and thickness of the product. At present, certain prior art equipment includes two X-ray sources for irradiating a blood transfusion bag. By utilizing the present unique inventive scheme, the same equipment can use one X-ray source with a reflector, rather than two X-ray sources; the advantages are obvious.

While the invention has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention.

Claims

1. A system for irradiating a product with a source of radiation comprising, in combination,

a) a source providing radiation to penetrate and irradiate the product; some of the radiation and exiting the product; and

b) a reflector of a high density, low Z material positioned to receive radiation exiting the product and to reflect back a some portion of the radiation exiting the product to re-irradiate said product.

2. A system as in claim 1wherein the product has a top surface, an opposite bottom surface, and side surfaces wherein

a) the source of radiation is positioned to irradiate the top surface of the product and penetrate the product; some of said radiation exiting on said opposite bottom surface and the side surfaces of the product; and wherein

b) said reflector is positioned to receive and reflect back radiation exiting said product to re-irradiate the product from said bottom and side surfaces.

3. A method of irradiating a selected product comprising, in combination,

a) directing radiation of sufficient energy to cause some of said radiation

penetrate and exit the product;

b) positioning a reflector of a selected high density, low Z material at least three quarters inch thick to receive radiation exiting the product and to reflect said radiation; and

c) directing the reflected radiation back to irradiate said product.

4. A system as in Claim 1 wherein said reflector comprises boron carbide of at least three quarters inch in thickness.

5. A system as in Claim 1wherein said reflector comprises boron of at least three quarters inch in thickness.

6. A system as in claim 1wherein said reflector comprises carbon of at least three quarters inch in thickness.

7. A system as in Claim 1 wherein

a) the product has a top surface, a bottom surface and side surfaces and the radiation enter the top surface;

b) said reflector comprises a low Z, high density material configured to reflect

ray to the bottom surface of the product as well as to the sides of the product.

8. A system as in claim 1 wherein the reflector may be of boron, boron carbide or carbon of at least 10 cm in thickness to reflect X-rays or gamma rays.

9. A system as in claim 8 wherein the reflector is configured to reflect the radiation to selected areas of the product being irradiated.

10. A system for irradiating with X-rays a product which product has top, bottom and sides surfaces comprising, in combination,

a) a source of for providing X-rays directed to irradiate the top surface of the product;

b) said source of X-rays providing X-rays suitable for penetrating at least 4 cms of water equivalent product;

c) a reflector of a high density, low Z material positioned to receive X-rays exiting the product and to reflect back a major portion of the X-rays exiting the product to re-irradiate said product;

d) said reflector being of boron carbide and being of a thickness of at least 10 cms in thickness,

e) said reflector being configured to reflect X-rays back to the sides of the product as well as to the bottom of the product; and

f) said reflector being positioned adjacent the bottom surface and side surfaces.

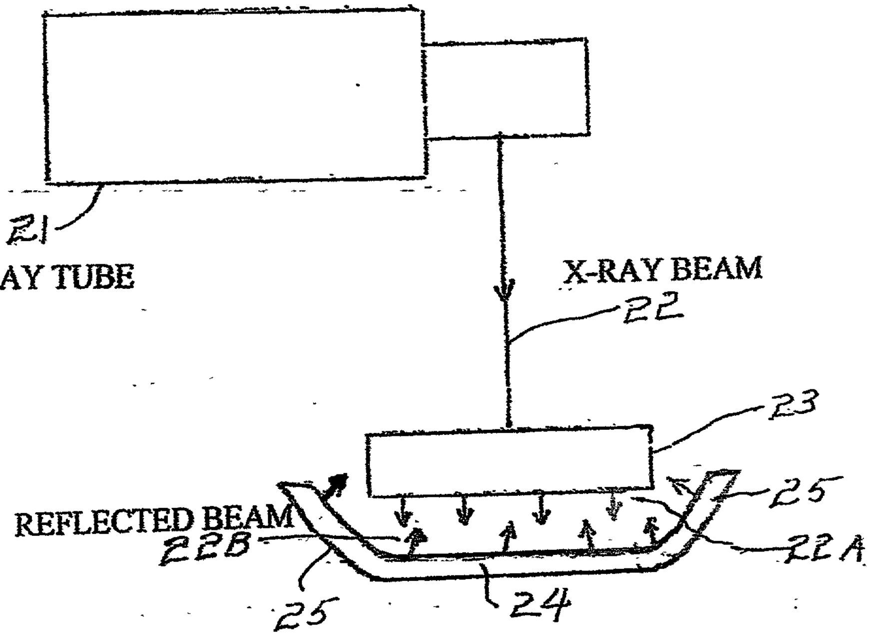
11. A system as in Claim 10 wherein said reflected X-rays are selectively directed to specific areas of the product.

12. A system as in Claim 1 wherein said reflector is formed as recess for containing the product.

Abstract:

A system and method for utilizing a radiation source for irradiating a product, the system including an radiation reflector comprised of a low Z, high density material. The reflector is positioned to receive radiation penetrating and exiting the product, and the reflector reflects the radiation back to the product to provide additional irradiation energy to the product.

Fig.1



A Dose Distribution in a Water Phantom
Irradiated by a 160 KV X-ray Tube

	WITHOUT REFLECTOR	10cm BORON CARBIDE REFLECTOR
TOP SURFACE PHANTOM	100%	100%
MIDDLE OF PHANTOM	76%	90%
BOTTOM SURFACE OF PHANTOM	49%	70%

Fig 2

Fig 3

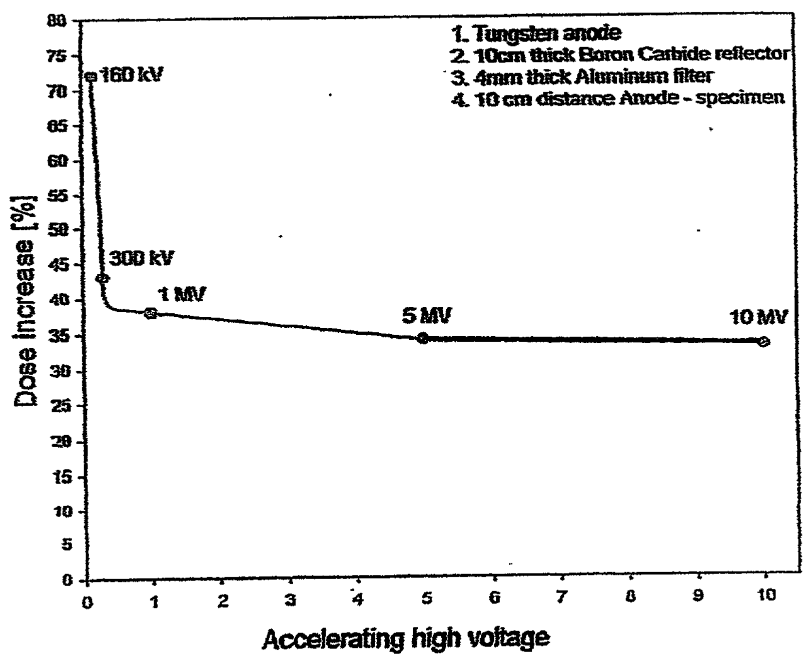


Fig 4

DOSE DISTRIBUTION IN A 4CM WATER SPECIMEN POSITIONED BETWEEN A 160 kV X-RAY TUBE AND A BORON CARBIDE REFLECTOR

		Distance 8"	Distance 9"	Distance 10"	Distance 11"	Distance 12"	Distance 14"	Distance 16"
Dose Ratio Top/Bottom 1cm water layers	5cm Boron Carbide	1.32	1.22	1.21	1.17	1.22	1.23	1.21
	10cm Boron Carbide	1.30	1.21	1.21	1.17	1.18	1.22	1.20
Dose Ratio Bottom/Top 1cm water layers	5cm Boron Carbide	0.76	0.82	0.83	0.85	0.82	0.81	0.82
	10cm Boron Carbide	0.77	0.82	0.82	0.85	0.85	0.81	0.83

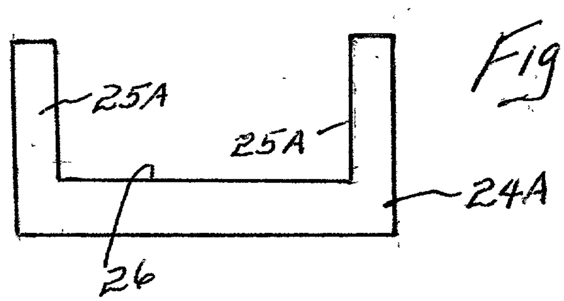


Fig 1A

** >Please type a plus sign (+) inside this box → [+]

PTO/SB/01 (3 97)
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DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION

[X] Declaration Submitted with Initial Filing OR [ ] Declaration Submitted after Initial Filing

Attorney Docket Number	
First Named Inventor	Gueorguiev,Gueorgui
COMPLETE IF KNOWN	
Application Number	
Filing Date	
Group Art Unit	
Examiner Name	

As a below named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

Irradiation System and Method Using X-ray Reflector and Gamma Ray Reflector

(Title of the Invention)

the specification of which

[X] is attached hereto

OR

[ ] was filed on (MM/DD/YYYY) [ ] as United States Application Number or PCT International Application Number [ ] and was amended on (MM/DD/YYYY) [ ] (if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37 Code of Federal Regulations, § 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code §119 (a)-(d) or § 365(b) of any foreign application(s) for patent or inventor's certificate, or §365 (a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Priority Not Claimed	Certified Copy Attached? YES	NO
			[ ]	[ ]	[ ]
			[ ]	[ ]	[ ]
			[ ]	[ ]	[ ]
			[ ]	[ ]	[ ]
			[ ]	[ ]	[ ]
			[ ]	[ ]	[ ]

[ ] Additional foreign application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto

I hereby claim the benefit under Title 35, United States Code § 119(e) of any United States provisional application(s) listed below.

Application Number(s)	Filing Date (MM/DD/YYYY)	
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DECLARATION — Utility or Design Patent Application

I hereby claim the benefit under 35 U.S.C. 120 of any United States application(s), or 365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

U.S. Parent Application or PCT Parent Number	Parent Filing Date (MM/DD/YYYY)	Parent Patent Number (if applicable)

☐ Additional U.S. or PCT international application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

As a named inventor, I hereby appoint the following registered practitioner(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith: ☐ Customer Number [ ] → Place Customer Number Bar Code Label here
OR
☒ Registered practitioner(s) name/registration number listed below

Name	Registration Number	Name	Registration Number
Leo J. Aubel	18,382		

☐ Additional registered practitioner(s) named on supplemental Registered Practitioner Information sheet PTO/SB/02C attached hereto.

Direct all correspondence to: ☐ Customer Number or Bar Code Label [ ] OR ☒ Correspondence address below

Name	Leo J. Aubel				
Address	111 Rivershire Lane				
Address					
City	Lincolnshire	State	IL	ZIP	60069
Country	USA	Telephone	847-634 8923	Fax	847-634-8985

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Name of Sole or First Inventor: ☐ A petition has been filed for this unsigned inventor

Given Name (first and middle [if any])	Family Name or Surname
Gueorgui	Gueorguiev

Inventor's Signature	G. Gueorguiev			Date	11/8/2000
Residence: City	Gainesville	State FL	Country USA	Citizenship	Bulgaria
Post Office Address	4019 SW 15th Lane #E				
Post Office Address					
City	Gainesville	State	FL	ZIP 32607	Country USA

☐ Additional inventors are being named on the ____ supplemental Additional Inventor(s) sheet(s) PTO/SB/02A attached hereto